GOLDEN GATE VIADUCT
Yellowstone Roads and Bridges
Spanning a ravine on Grand Loop Road
Yellowstone National Park
Park County
Wyoming

HAER No. WY-46

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HISTORIC AMERICAN ENGINEERING RECORD

GOLDEN GATE VIADUCT

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Location: Spanning a ravine on Grand Loop Road, 4.5 miles south of Mammoth Hot Springs, Yellowstone National Park, Park County, Wyoming
UTM: Mammoth, WY, Quad. 12/521980/4975620

Date of Construction: Original structure, 1885; rebuilt, 1900; replaced, 1933; modern structure, 1977

Owner: Yellowstone National Park, National Park Service

Use: Vehicular bridge/viaduct

Designer: Federal Highway Administration

Significance: The present Golden Gate Viaduct occupies the location of several historic viaducts. The original structure at Golden Gate was built in 1885 by the Army Corps of Engineers, which was responsible for early road-building projects in the national parks.

Project Information: Documentation of Golden Gate Viaduct is part of the Yellowstone Roads and Bridges Recording Project, conducted during the summer of 1989 by the Historic American Engineering Record, a division of the National Park Service, under the co-sponsorship of Yellowstone National Park, the NPS Roads and Bridges Program, and the NPS Rocky Mountain Regional Office, Denver. Historical research and written narrative by Mary Shivers Culpin, Historian, NPS Rocky Mountain Regional Office. Engineering description by Steven M. Varner, Virginia Polytechnic Institute. Edited and transmitted by Lola Bennett, HAER Historian, 1993.

HISTORY OF GRAND LOOP ROAD

(See HAER WY-24, Yellowstone Roads and Bridges.)

DESIGN AND CONSTRUCTION OF GOLDEN GATE VIADUCT

In 1883 work began on a new route from Mammoth Hot Springs to Gardiner, Montana, through the Golden Gate and the West Fork of Gardner River. The project was completed in seven months. Twelve hundred and seventy-five pounds of explosives were used and over 1,300 drilled shots were fired. As a result, 14,000 cubic yards of solid rock was excavated, in addition to a large amount of broken and crushed rock. This dangerous section of road was completed without loss of life or injury. The new road reduced the route by 1½ miles and the time to many areas in the park from two hours to a half day depending on the type of wagon and load. The reduced ascent of 250 feet to Swan Lake plateau enabled loaded wagons traveling in opposite directions to now pass with relative ease. The near-vertical stone walls of the canyon prevented an excavated roadway, thus a 228-foot wooden trestle was built to carry the roadway. Lt. Dan Kingman of the Army Corps of Engineers noted in his report for 1885 that the "natural stone monument at the end of the trestle" marked what "visitors have called the Golden Gate."

Four years after the completion of the road, the wooden trestle was strengthened by placing new timber supports and road-bearing cross beams. In 1899 Army Corps officer Hiram Chittenden described the road as follows:

> ... through this canyon is mostly cut in side of cliff. For 200 feet it passes over a wooden bridge. This bridge is about fifteen years old and has reached its limit of safety. It will have to be condemned by the close of the season. The situation is such than an accident here would have appalling consequences. It is proposed to put in a series of concrete arches, covered with regular macadam roadway 16 feet wide and a solid parapet 3 feet high. The cost will be in the neighborhood of $10,000. The road through the canyon is in most places too narrow for teams to pass each other, and there are two short turns where the view ahead is abruptly and completely cut off. It is proposed to widen the road so that it shall everywhere be passable by two teams abreast, and to make it much wider at the sharp curves. At the same time the steep grade will be eliminated and the whole made to conform to the grade and approaches of the new bridge. This will be solid rock work and very costly.[1]

The next year, Chittenden felt that the bridge excited "general uneasiness and concern among the traveling public, and although still safe it was felt that its reconstruction could not long be deferred anyway and might as well be taken up at once ..."[2] Chittenden made a decision to build a concrete structure.

> It was decided to build the new viaduct in a series of arches. The piers were spaced 18 feet from center to center, and were made 3 feet thick and carried down to firm rock. The rise of the arches was fixed at 2 feet; the thickness at the crown at 12 inches and at the springing line at 18 inches. The arch was reinforced with wire netting made of No. 8 B.G. steel wire with meshes 5 by 1 5/8

> inches, the long dimension of the mesh being parallel to the axis of the bridge. The netting was placed 4 inches above the lower surface of the arch and extended 3.75 feet on each side of the crown. A parapet wall 42 inches high above the top of the arch was provided on the side opposite the cliff. It was given a thickness of 12 inches at the top and 16 inches at the crown of the arch. To strengthen it further, four pieces of 60 pound steel rail 4 feet long was placed obliquely so as to extend through the concrete. The materials used were Atlas Portland cement, and a natural mixture of gravel and sand found on the Swan Lake flat, 3/4 of a mile from the work. The mixture seemed comparatively free of dirt and was used just as taken from the pit. The proportions of the mixture were on a basis of 1 cement, 2 sand, and 4 gravel.[3]

Most of the time, particularly during the cement work, a gale roared through the canyon, forcing the crews to begin work at daybreak and end about 11 a.m. Besides the wind, the lack of rain created an excessive dust problem. Working in such a restricted area and the ever-present danger of falling from the cliff made this project a dangerous one. Tourist traffic was rerouted on a temporary road via Snow Pass for four weeks. For about the last month of construction the traffic moved through the canyon.[4]

It was during this construction that a picturesque landmark, the large stone at the entrance to the canyon, received it's first instance of special treatment.

> One interesting feature of the later work was the removal of the large rock which stood at the entrance to the old bridge and partially blocked the roadway which divided it and the cliff. The changes involved in the new structure necessitated the removal of this rock. As it was the unanimous desire of those familiar with the park that this unique and picturesque feature be retained, the rock was broken off, lifted about 6 feet to the new grade, moved out about 6 feet and down the Golden Gate Viaduct the road about the same distance where it was set up on a new foundation, consisting of a square column of concrete 3 by 3 feet and 24 feet high. The whole foundation was then covered up, so as to remove all evidence of its artificial character. This rock weighed about 23 tons and its removal took place on the steep face of an unstable cliff, it had to be managed with great care. It was done under the direction of Foreman Robert Walker, with a force of 4 men. The whole operation consumed 5 days and cost $80.[5]

Upon completion of the 2,000 feet of new roadway, grades through the canyon were reduced and the newly widened lanes allowed teams to pass one another safely.[6] In 1910 the Golden Gate Viaduct was called the "most notable engineering feature of the whole road system".[7]

For the next few decades, Chittenden's viaduct served the traveling public. In 1926 plans were begun for its improvement using National Park Service day forces, but by 1930 a request was made for additional help from Bureau of Public Roads (BPR) engineers. The BPR recommended a tunnel at station 419-420, a viaduct at station 423+10 to 425+95, using sixteen 18-foot spans of steel and reinforced concrete, concrete box and metal pipe culverts with masonry headwalls, masonry retaining wall and hand-laid rock embankment. The project was awarded to Morrison-Knudsen Company on October 20, 1932.[8]

The contractor set up camp in a previously-occupied camp at the right of station 515, about one mile below the end of the work. Frame bunkhouses, offices and a mess house were constructed. Several tents served as additional bunkhouses. Approximately fifty-five men worked on this project, which began on October 29, 1932. By the middle of December, excavation of the east portal of the tunnel was finished and the actual tunnel project began.

> Small pioneer tunnels were driven to a distance of 28 feet on each side at spring line and then cross cut at the inside end and the excavation of the roof made, working outward toward the portal. This was done to avoid overbreak and a possible cave-in as the rock was badly seamed and shattered. As the rock was excavated, timber lining was placed consisting of 12x12 posts and cross members set at 4 feet intervals, with timber logging filling the space behind. By February 19, 1933, tunnel excavation was completed with the exception of the last seven feet on the upper end. In removing this last seven feet section, a cave-in or slide occurred and this portion sheared off, falling onto the road in front of the tunnel. It was necessary at this time for the shovel to move around the point to the outside at upper end of tunnel and load this slide material, but weather conditions were so severe the men could not stand to work there, so all activities were discontinued until the weather moderated.
>
> During the period from December 1, 1932 to February 19, 1933, weather conditions were very severe with considerable snow and extreme cold, the thermometer registering a minimum of 62 degrees below zero at one time, and a high wind blowing almost incessantly through the canyon. Great difficulty was experienced in keeping air lines from freezing up and in getting machinery started in the mornings.
>
> By March 9, 1933, weather conditions had modified sufficiently to permit work to be carried on and excavation was timed on the tunnel. Excavation of the tunnel was completed on March 20, 1933, with a total length of 90 feet as compared with the original planned length of 100 feet.
>
> During the month of May, water from melting snow running into the cracks and crevices above the east portal of tunnel and then freezing and thawing, caused the rock to start working at this point and a few small slides occurred and timbering in the tunnel was observed to be taking considerable weight. Additional posts and braces were set to strengthen the timbering and men were set up to work prying off rock to reduce the weight above the timbering in an attempt to avoid a cave-in, but on May 22, 1933, the tunnel caved in resulting in the loss of all except 16 feet on the upper or west end. A change order was issued eliminating the completion of

> the tunnel from the contract, and the point where the tunnel was originally planned is now to be designated as a quarry site for surfacing and when completed, will be a daylight cut.
>
> After completion of the tunnel excavation on March 20, 1933, work was pushed on the viaduct in order to have the north half ready for traffic when the Park opened. Footings for columns were excavated and poured, steel columns set in place and cross girders and reinforcing steel placed. Pouring of concrete was carried on as fast as excavations were made and forms and steel placed. Aggregates for concrete were heated by heaping them on large pipes in which fires were kept burning. Water was heated with a coil and concrete was protected from freezing with canvas covering and oil stoves.
>
> The north half of the viaduct was completed on May 10, 1933, and opened to traffic on May 26, 1933. The south half was completed on July 15, 1933.[9]

The 1933 structural steel and reinforced concrete viaduct consisted of sixteen spans with a length of 18' per span was built over and outside of the Army-built viaduct it replaced. It was independent of the old viaduct for support. The 24-foot wide roadway extended from stat 423+10 to 425+95. All drainage was accommodated by corrugated metal pipes with masonry headwalls, with the exception of one 4x4 concrete box culvert with masonry headwall built at station 406+75 in Glen Creek.[10]

The sand came from a pit approximately five miles north of the project and the coarse aggregate came from the excavated tunnel material. As part of the project, old roads and old drainage structures were obliterated. The total project was completed on August 16, 1933, at a cost of $115,630.93.

The final surfacing was completed on July 17, 1934, resulting in a 22-foot wide (shoulder-to-shoulder) road that had a 4-inch base of 1½-inch maximum size aggregate and 1-inch top of 1-inch maximum size aggregate.[11] Also in 1934, a stone parapet was added at the location of the tunnel and the wall was repaired when it had settled. Excess stone from previous masonry work and stone obtained from the bed of Glen Creek near the foot of Rustic Falls were used in the construction work.[12]

In 1949 the roadway through Golden Gate Canyon received bituminous surfacing as part of a larger surfacing project from Mammoth Hot Springs to Firehole Cascades. The project, which was paid for out of park maintenance funds, was awarded to Peter Kiewett Sons Company of Sheridan, Wyoming. The purpose of the project was to "prolong the life of the existing pavement and reduce the cost of maintenance on this section," even though the engineers knew that the road "will ultimately require widening to a higher standard, at which time it will be necessary to widen the shoulders and improve the bituminous pavement."[13]

In 1959 an earthquake centered near the park's western boundary caused considerable damage to the masonry guard rails and embankments near Gibbon Falls, in the Golden Gate Canyon, at Undine Falls and Overhanging Cliff. Much of the guard wall "had fallen off or [was] cracked in the joints, and embankments had slipped and bulged." In the Golden Gate Canyon, slides blocked the road and portions of the guard rail were lost or damaged to such an extent that replacement of the guard rail was required. Day labor work in the Golden Gate Canyon covered slide removal and scaling, breaking up and relaying the old surface and resurfacing with 2-inch bituminous mat, and replacement of 950.1 linear feet of rustic log guardrail. McLaughlin Construction Company of Livingston, Montana, was awarded the contract for the masonry replacement work.[14]

The contractor's work was described as follows:

> Rehabilitation and reconstruction of stone masonry guard wall included correction of alignment and elevations, construction of reinforced foundations for all new stone masonry, stabilization of embankments by new reinforced concrete base under bulged sections, and the grouting of slipped embankments above and around such bulged sections, ... The Park granted permission to the contractor to salvage some additional rocks for the masonry from old quarries and storage dumps near Norris Geyser Basin, Midway Geyser Basin, and Undine Falls. ... For safety reasons work was started in most places by removing old damaged masonry along the road edge above the embankments. New foundations were established along the corrected lines and elevations. The embankment above and around bulges and cavities was stabilized with grout and after curing of the concrete, the bulges down under were excavated and properly repaired. All new guard wall foundations were made to overlap into solid ground or into rock formations, spanning over 80 to 170 feet of existing embankment[15]

The work was completed during the 1960 season.[16]

In 1977 a new six-span continuous girder bridge with concrete deck replaced the old viaduct. The 327-foot long, two-lane bridge has a width of 30' curb-to-curb and steel on concrete base railings, 2'-5" above the roadway. The bridge is in good condition. Falling rocks in 1984 necessitated the repair to holes in the deck and damage to the stone parapets.[17]

ENDNOTES

1.Hiram Chittenden, Improvement of the Yellowstone National Park, Including the Construction, Repair and Maintenance of Roads and Bridges, in Annual Report of the Chief of Engineers for 1899, Appendix EEE, (Washington D.C.: Government Printing Office, 1899) p.10.

2.Chittenden, Improvement of the Yellowstone National Park, in Annual Report of the Chief of Engineers for 1899, Appendix FFF, (Washington D.C.: Government Printing Office, 1901) pp.3778-79.

3.Ibid.

4.Ibid.

5.Ibid.

6.Ibid.

7.M. Eldridge, "Touring Yellowstone Park on Government Highways."

8.E.O. Anderson, "Final Construction Report (1932-33) Project "E" 1-A4 Grading Mammoth Hot Springs-Norris Junction, Grand Loop National Park Highway, Yellowstone National Park, Wyoming."

9.Anderson, "Final Construction Report (1932-33) Project "E" 1-A4 Grading, Mammoth Hot Springs-Norris Junction, Grand Loop National Park Highway, Yellowstone National Park, Wyoming."

10.Ibid.

11.Anderson, "Final Construction Report, 1933-1934, Project NR 1-A1, A3, A4, A5 Surfacing, Grand Loop Highway, Yellowstone National Park, Wyoming."

12.C.F. Capes, Bureau of Public Roads, to Roger Toll, Superintendent of Yellowstone National Park, 17 July 1934.

13.Anderson, "Final Construction Report (1948-49) on Grand Loop National Park Highway - Wyoming, Project 1-A, B, C-1 Reseal, Yellowstone National Park, State of Wyoming, February 8, 1950."

14."Completion Report Narrative, Account 523.35 - Emergency Roads and Trails Reconstruction, Earthquake Damage."

15.Ibid.

16.Ibid.

17."Yellowstone National Park, Parkwide Road Engineering Study," Volume I, Federal Highway Administration, Western Direct Federal, U.S. Department of Transportation, 1986.